ILC POSITRON SOURCE ISSUES

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Positron Sources - Conventional

- Use multiGeV electrons impinging on a high-Z target (SLC 30 GeV, 4E10 120HZ, 6rl ; ILC 6.2 GeV 4.5 rl, 2E10 , 2820 x 5 Hz)
- SLC target
  - Target 76W24Re, approx 3 inches diameter
  - Beam spot “circular” around edge of target (rotating target , 30RPM, ~0.1 m/s)
  - Target failed in 4 years, probably because of shock due to beam
  - SLC target experience a reference point

Positron Sources (Undulator)

- Use very high energy electron beam passing through undulator to make multi-MeV photons (150 -250 GeV electrons, 100 meter or more of undulators, can use ILC electron beam)
- Photons impinge on thin target (0.4 rl Ti)
- Photons can be made by Compton scattering lower energy electrons off a high power laser beam -difficult, Japanese
- Allows for the possibility of polarized positrons
- Beam powers about the same/ activation much lower

Positron Injection

SLAC
LLNL
UCB
BNL
Cornell
Daresbury
DESY (?)

A generic positron source.

How many are needed?

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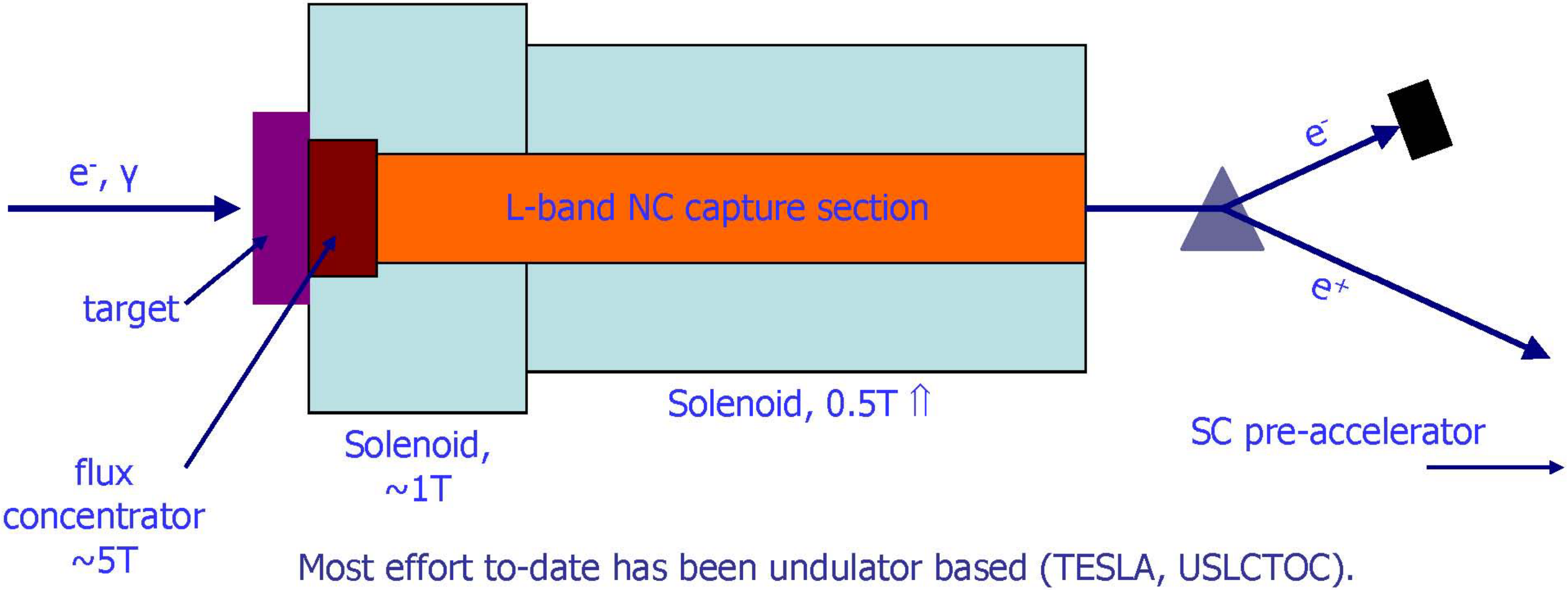
Approx 250 MeV of acceleration



Most effort to-date has been undulator based (TESLA, USLCTOC).

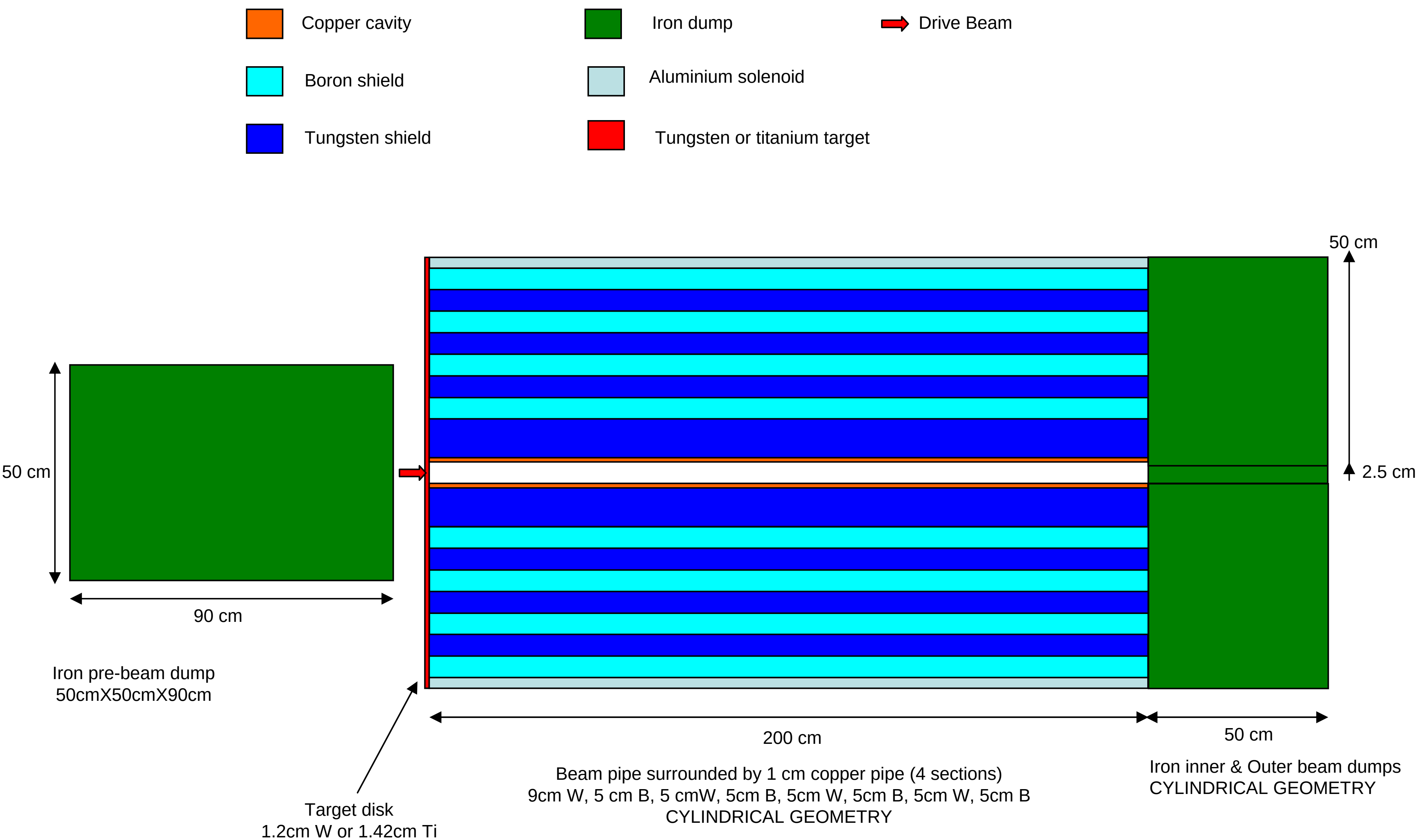
Conventional source feasibility is an important topic.

Questions

- Incoming average power is 280 kW for a conventional source and 220 kW for a undulator-based source
- Where does this energy go
  - How much into the L-band, vault air, vault ..
- Can we use a superconducting Adiabatic Matching Device
- Positrons do not have to be produced with the same bunch structure as the are used by the main linacs. Longer that 1 ms is better. 4 ms is good , 10ms is better.
- What L-band gradient can we get and how much do we need (present simulations use 10-25 MV/m).

Target Station Layout used for Simulations

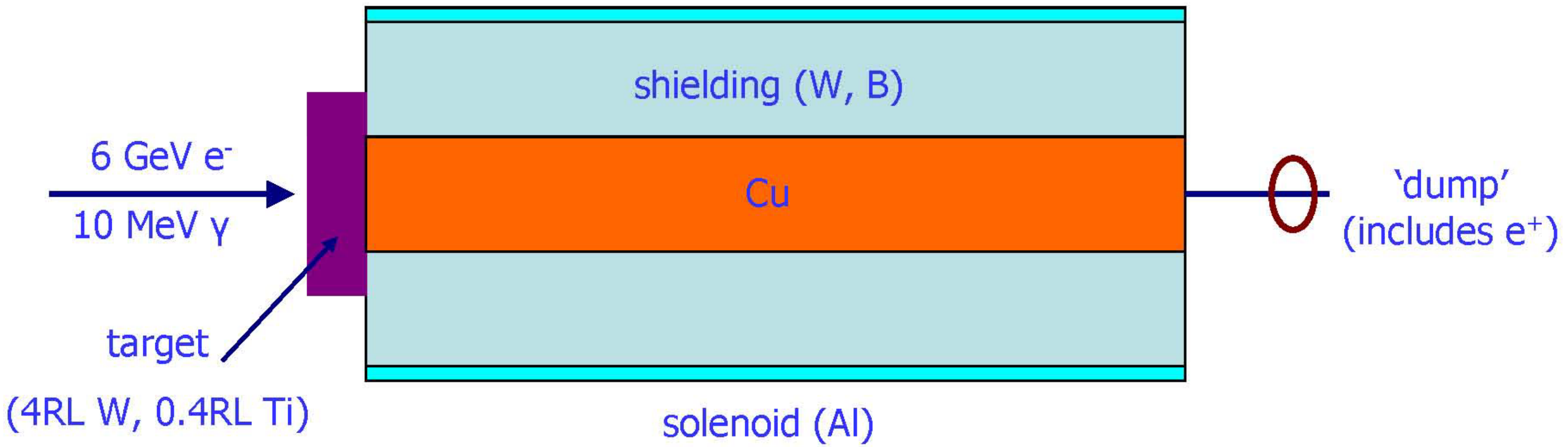
- Target disk 1 m in diameter, 1.2 cm of W (4 rl) or 1.42 cm of Ti (.4rl)
- Prebeam dump is an iron box 50 cm x 50 cm x 90cm (along beam axis)
- Inner dump 5 cm iron cylinder, 50 cm long, 2 meters from target
- Outer dump 1 m iron cylinder, 50 cm long, 2 meters from target (minus the inner dump)
- Cavity is 1 cm thick copper pipe 2 meters long in between the target and inner/outer dumps
- Shield is alternating “pipes” of W and B, 5 cm thick except the first W layer which is 9 cm thick. Shield goes from 3.5 to 47.5 cm in radius and is 2 m long
- Solenoid is 2.5 cm thick Al pipe 2 meters long



TARGET STATION (surrounded by 3 m thick concrete vault at +/- 7 m in x,y,z)

Simulation

Positron Vault Power Accounting



Beam	E	Power	target	Cu	dump	shield	solenoid	walls
e^-	6.2 GeV	280 kW	26 kW	118 kW	107 kW	4 kW	0.1 W	25 kW
γ	2-10 MeV	220 kW	23 kW	15 kW	164 kW	1 kW	0.2 W	17 kW

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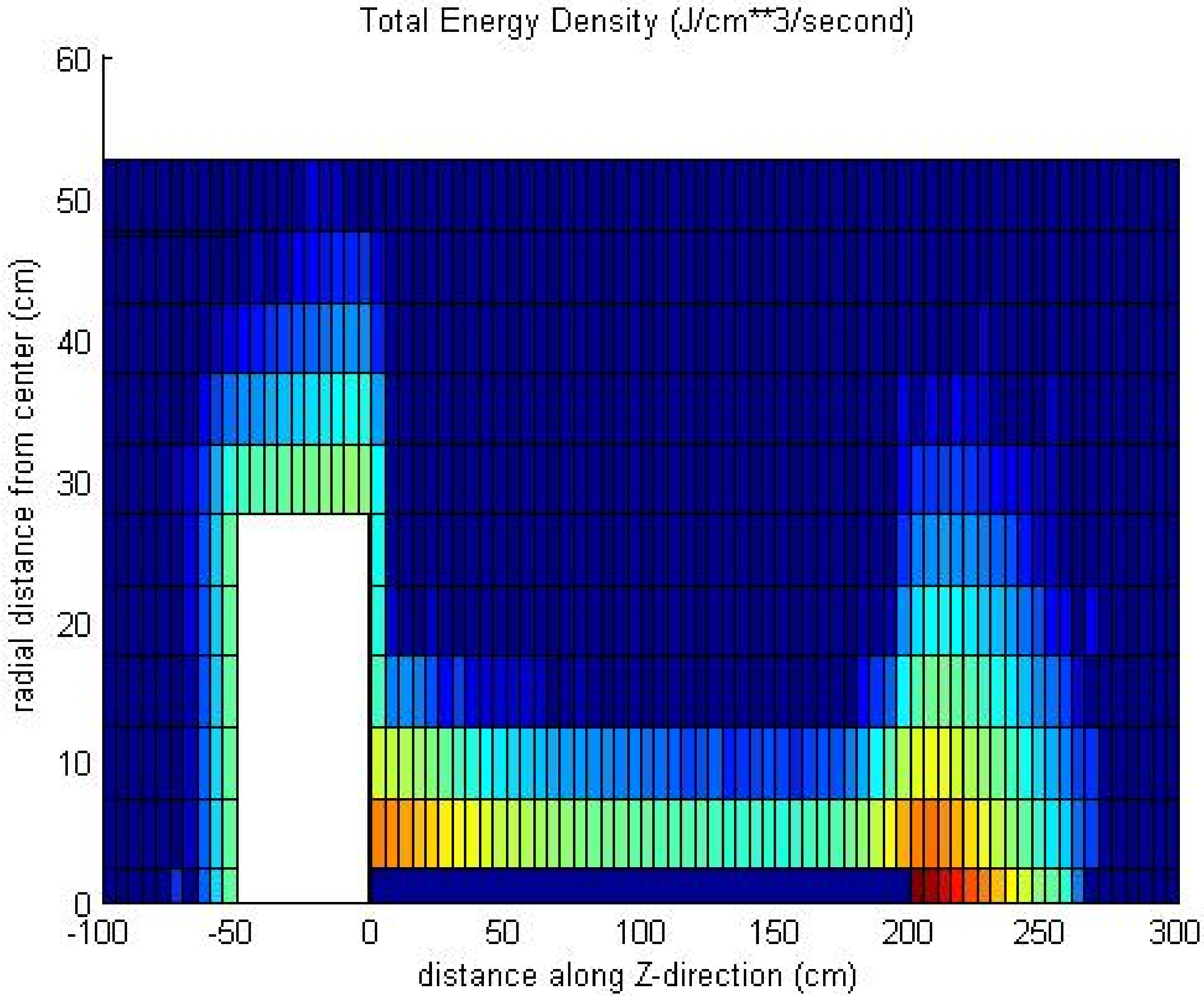
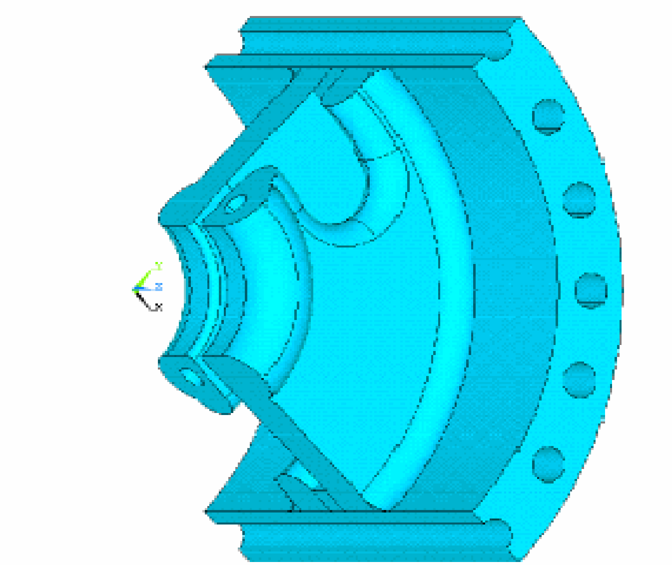
Simulation does not (yet) match details of geometry

Conventional – 6.2 GeV electrons, 280kW beam power, 4 rl W target, 2.5 tesla magnetic field between target and beam dump and inside solenoid and 5 cm thick "L-band" pipe

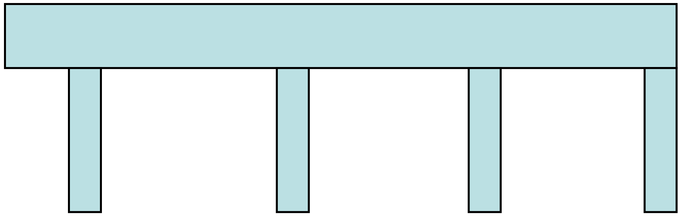
CONVENTIONAL SOURCE 6.2 GeV electron energy, 500 particles, 2.5 T Magnetic field, 5cm cavity						
Region Description	Total Energy	EM Energy	Had. Energy	Tot E (W)	EM E (W)	Had E (W)
	Deposited %	Deposited %	Deposited %			
Outside Target Vault	0.000000	0.000000	0.000000	0.000	0.000	0.000
Target vault	0.036606	0.034652	0.001954	102.496	97.025	5.471
Target vault air	0.000479	0.000420	0.000059	1.342	1.176	0.166
Target	9.234789	9.234785	0.000004	25,857.408	25,857.397	0.011
L-band (0-50cm)	19.160089	19.149942	0.010146	53,648.248	53,619.839	28.409
L-band (50-100cm)	10.619056	10.610287	0.008769	29,733.357	29,708.803	24.553
L-band (100-150cm)	6.392559	6.386732	0.005827	17,899.165	17,882.849	16.316
L-band (150-200cm)	5.556567	5.549655	0.006913	15,558.388	15,539.033	19.355
Solenoid	0.000047	0.000026	0.000022	0.133	0.072	0.060
Inner Dump (5cm dia.)	38.701612	38.668700	0.032912	108,364.513	108,272.359	92.155
Outer Dump (5-50cm di	8.506562	8.481304	0.025258	23,818.374	23,747.652	70.722
Pre-beam dump	0.082322	0.082269	0.000053	230.502	230.354	0.148
Solenoid Shielding (W)	1.506546	1.502689	0.003856	4,218.328	4,207.531	10.798
Solenoid Shielding (B)	0.035429	0.007484	0.027945	99.201	20.954	78.247
TOTAL	99.832662	99.708944	0.123718	279,531.454	279,185.043	346.411


Total Energy Density (J/cm**3/second)
radial distance from center (cm)
60
50
40
30
20
10
0
-100
-50
0
50
100
150
200
250
300
distance along Z-direction (cm)

L-band Energy Deposition



Inner iris radius = 26 mm
Outer iris radius = 89 mm
Iris spacing = 115 mm
Effective iris thickness (along z axis) = 26 mm
Radial thickness of outer wall = 20 mm
Number of cells in first two SW cavities = 20



Running new FLUKA geometry as above
And dividing the irises into five sections (rings) each
(1.05, 1.05, 1.05, 1.05, 2.1) for heat deposition and temp rise

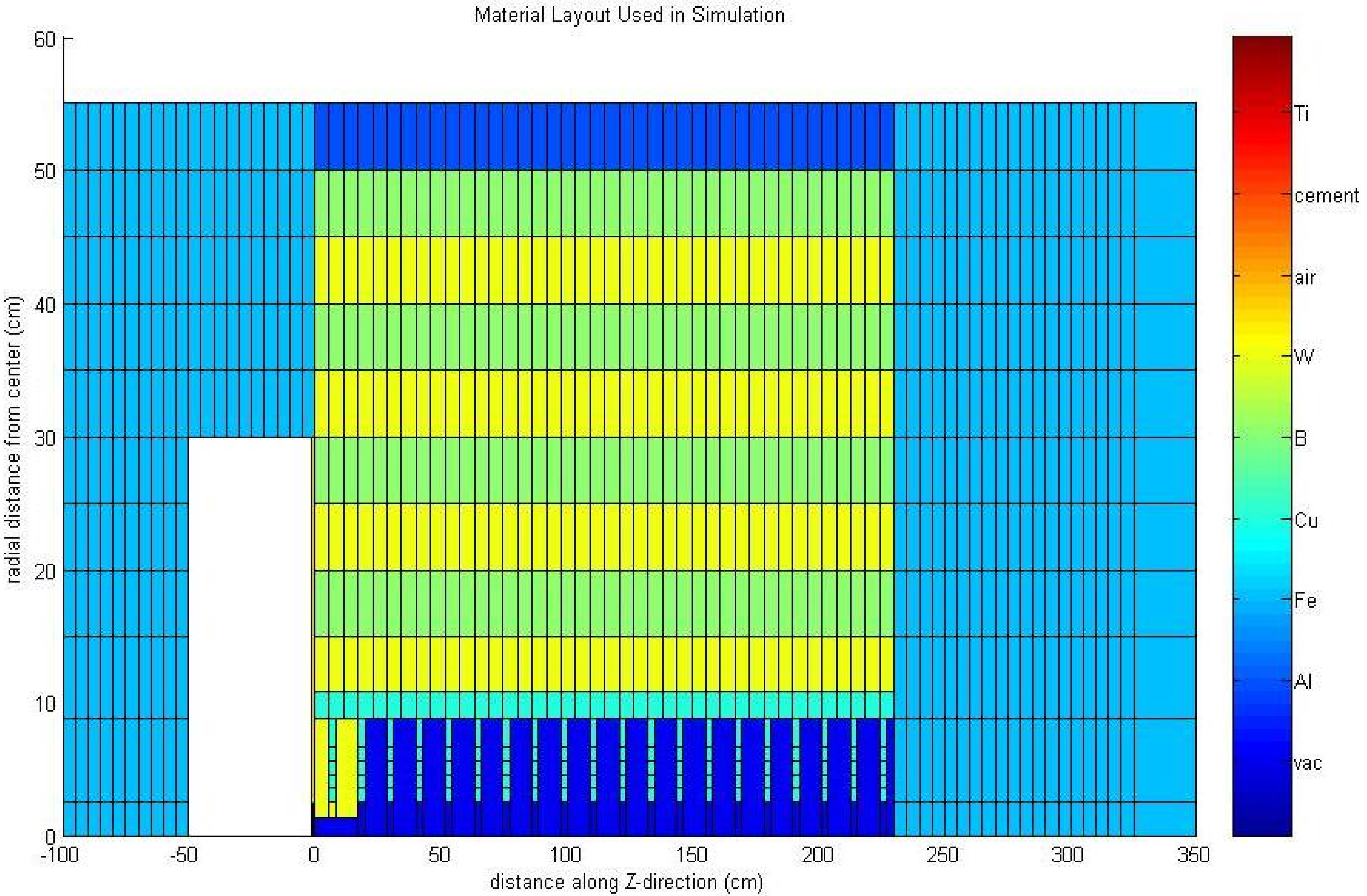
L-band Geometry

- 20 cells , 11.5 cm long
- Body IR=8.9 cm, OR=10.9 cm
- Irises (20)
  - Thickness = 2.6 cm
  - IR = 2.6 cm , OR = 8.9 cm
  - 5 segments rings – IRs =2.6,3.65,4.7,5.75,6.8 cm
- Collimator
  - IR 1.5 cm, OR 8.9 cm, from 0-17.25 cm , 1st iris exists

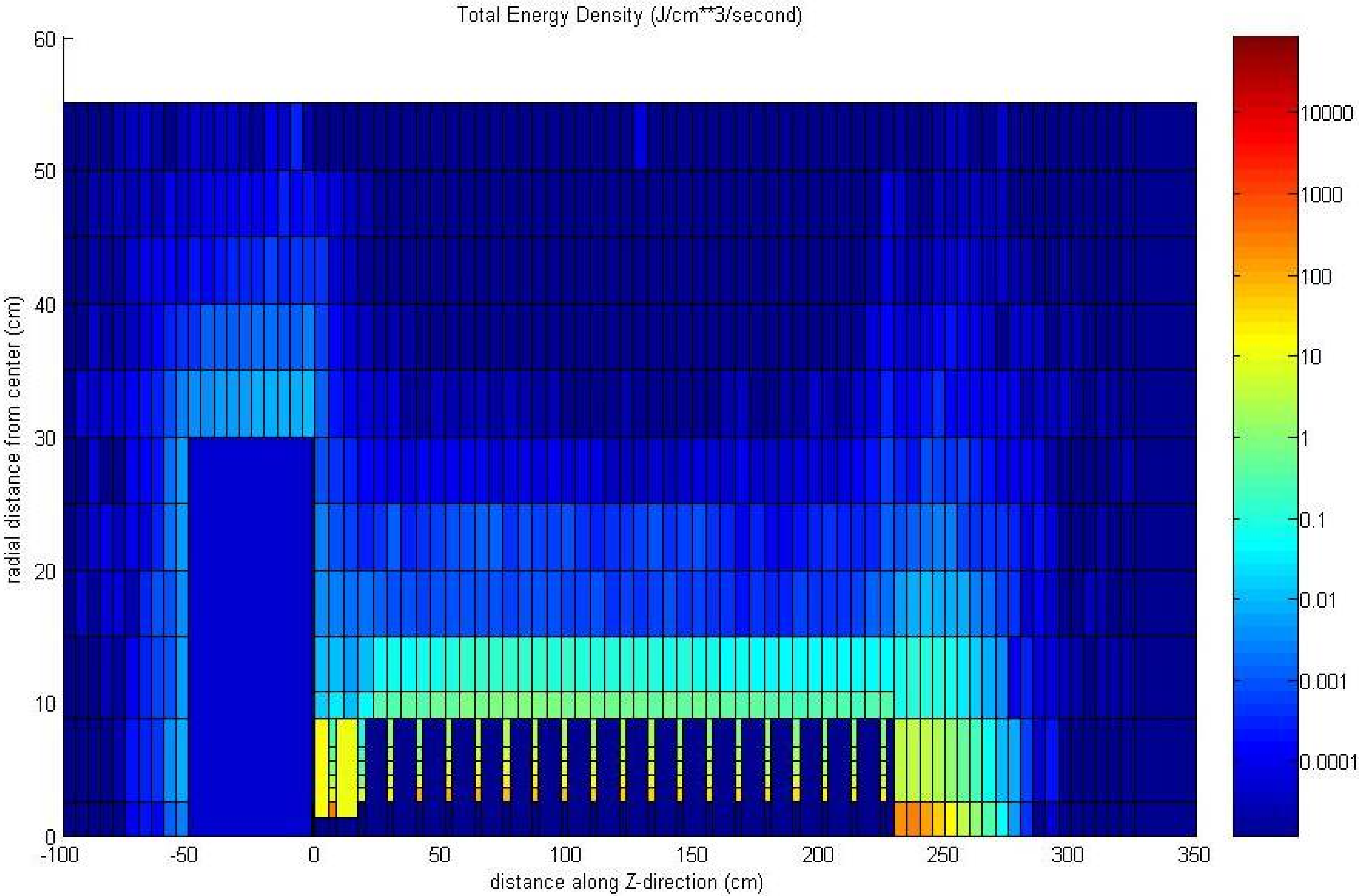
Beam Parameters

- Conventional
  - Beam energy = 6.2 GeV (+/- 0.1GeV gaussian)
  - Beam size = 1 mm sigma
  - Average beam power = 280 kW
  - Positron target = 1.35 cm/4.5 r.l. tungsten
- Undulator
  - Beam energy = 6 MeV (+/- 4 MeV flat dist)
  - Beam size = 1 mm sigma
  - Average beam power = 220 kW
  - Positron target = 1.42 cm/0.4 r.l. titanium

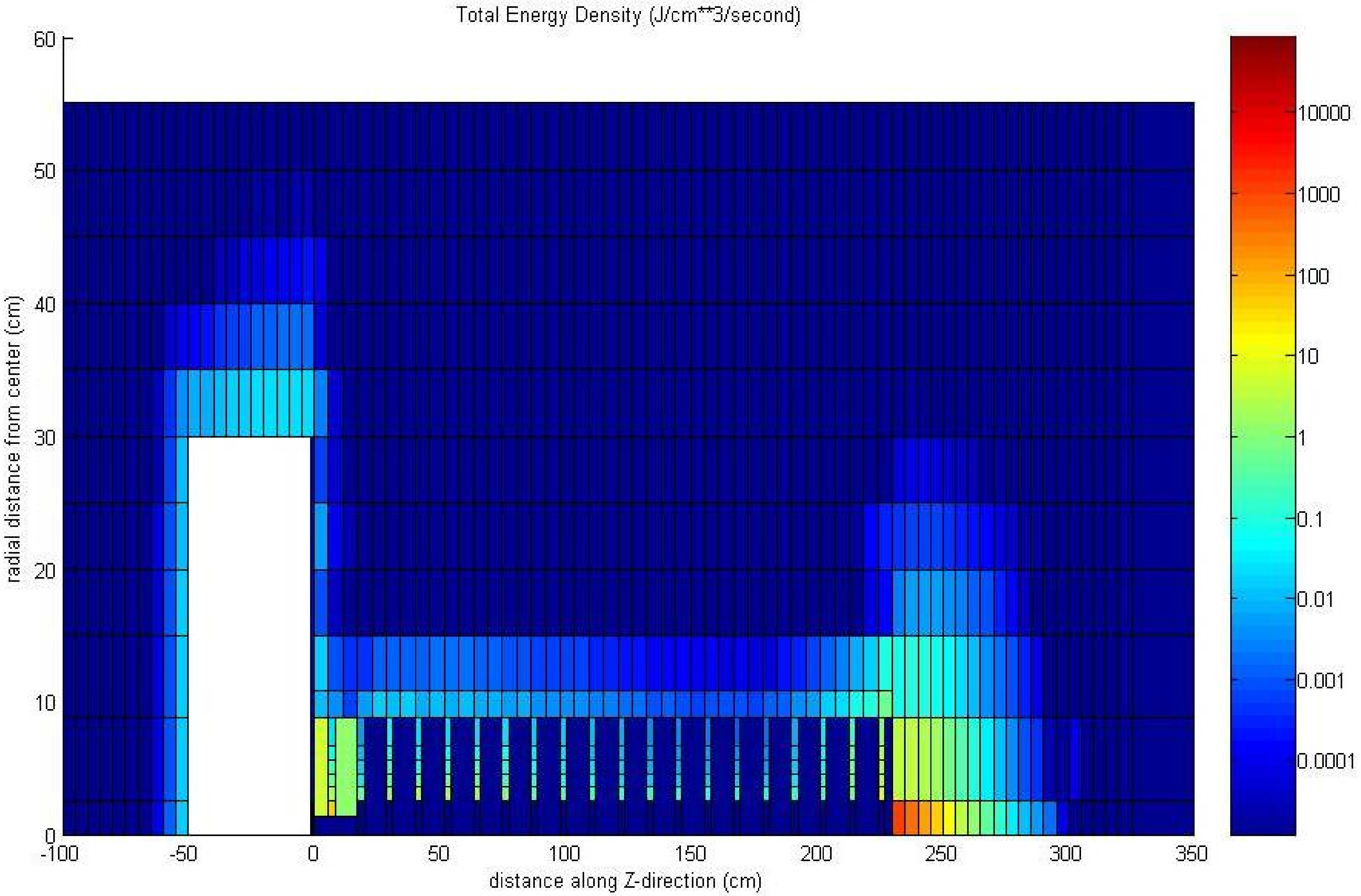
CONVENTIONAL GEOMETRY



Conv + Coll Energy Dep / cm**3



UND+COLL Energy Dep/ cm**3



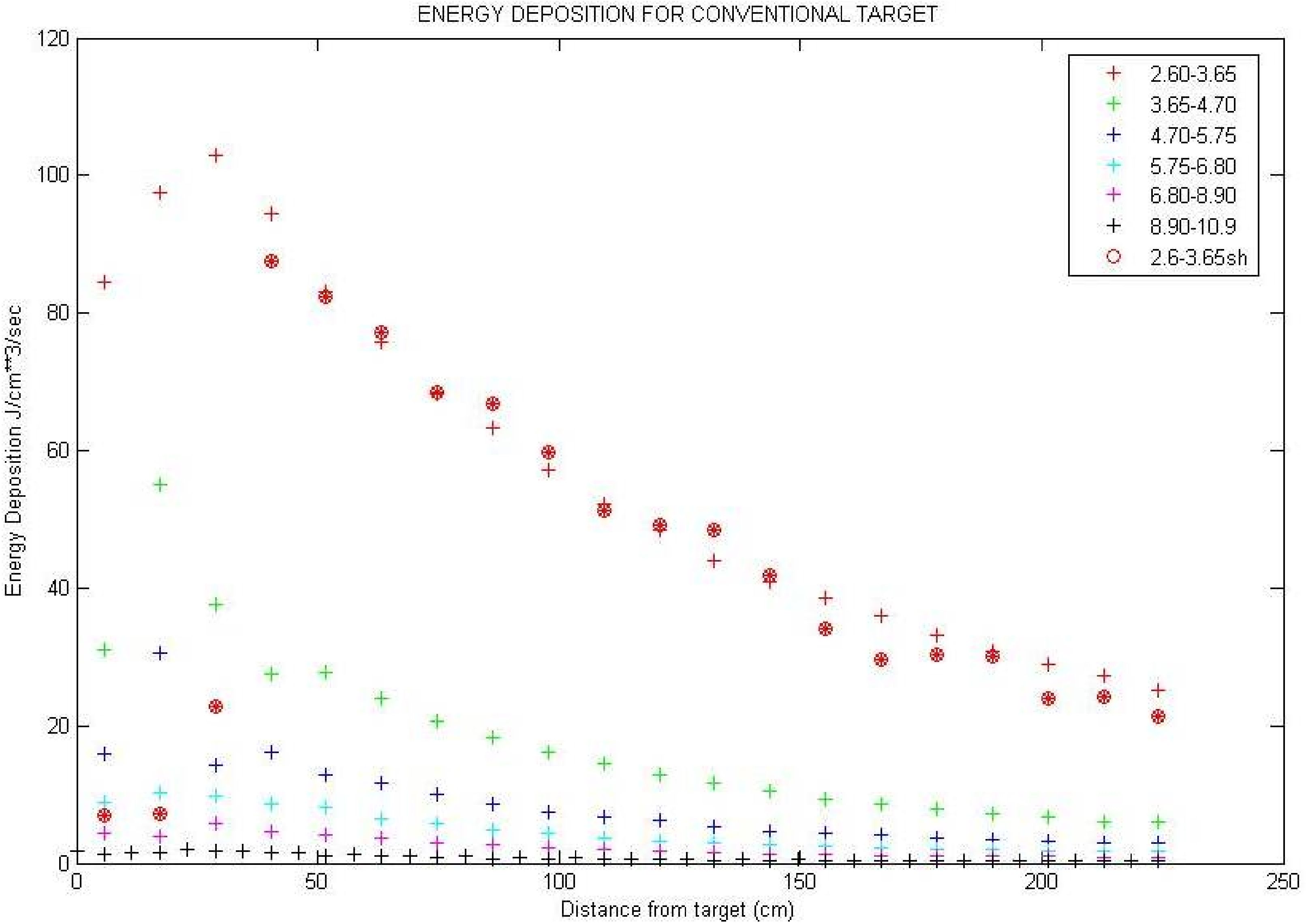
Overall Energy Depositions

	UNDULATOR	UND+COLL	CONV	CONV+COLL
#beam particles	2000000	2000000	5000	200
beam E (MeV)	2-10	2-10	6200	6200
Total beam power (kW)	220	220	280	280
Total Lband power (kW)	13.480	2.999	148.418	97.720
Total iris power (kW)	9.790	2.328	125.126	84.905
inner irises power (kW)	3.200	0.917	60.689	46.273
Collimator Power(kW)	0.000	12.024	0.000	54.374
Target Power Dep.(kW)	22.614	22.638	35.371	34.629

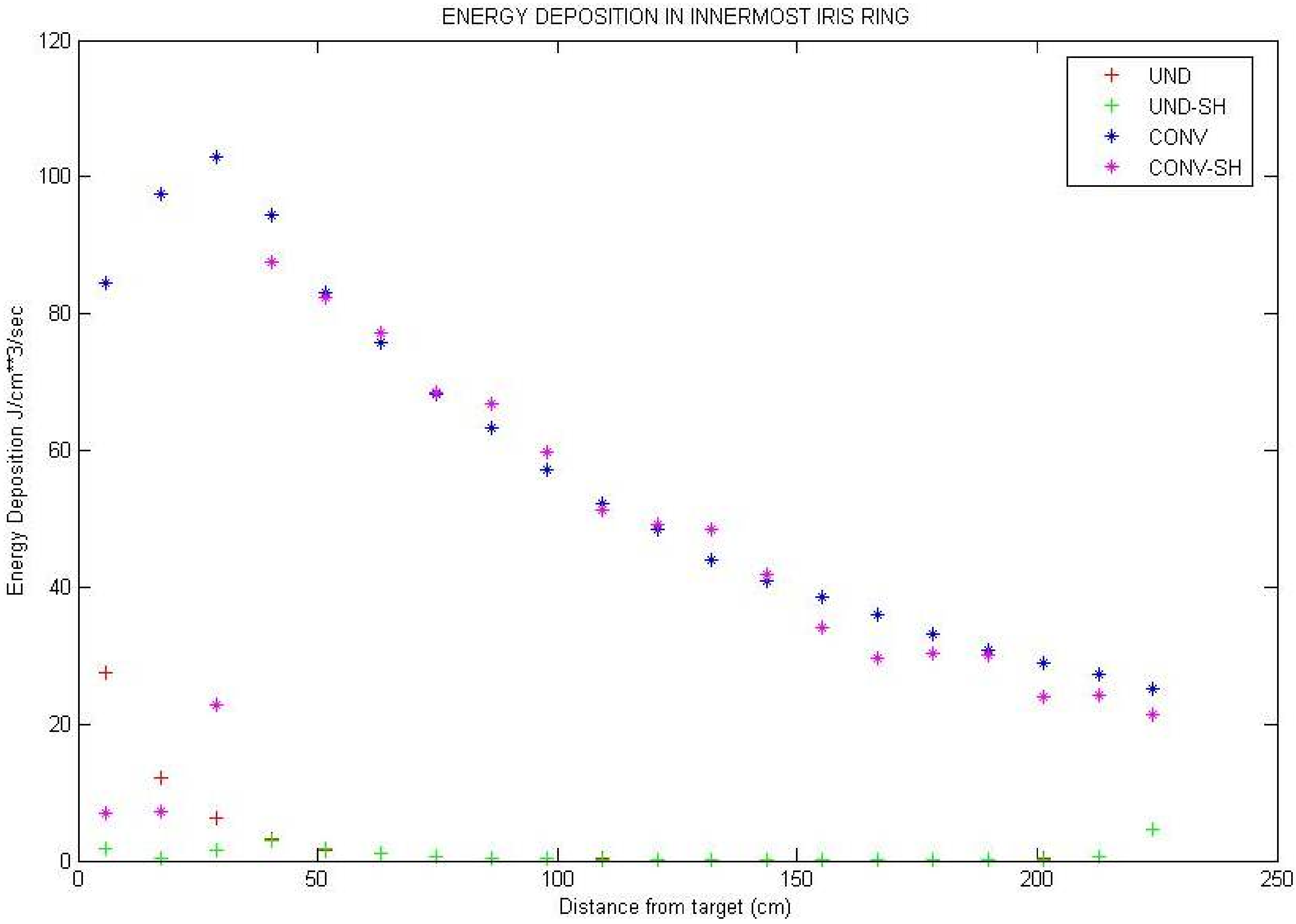
EDEP in innermost iris ring

			UNDULATOR	UND+COLL	CONV	CONV+COLL
			IRIS RING (r=2.6-3.65)			
IRIS #	Z1	Z2	UND POWER	UND POWER	CONV POWER	CONV POWER
			J/cm**3/sec	J/cm**3/sec	J/cm**3/sec	J/cm**3/sec
1	5.75	8.35	27.578	1.799	84.552	6.908
2	17.25	19.85	12.188	0.378	97.603	7.152
3	28.75	31.35	6.198	1.417	102.989	22.665
4	40.25	42.85	3.184	2.899	94.312	87.687
5	51.75	54.35	1.638	1.656	83.198	82.336
6	63.25	65.85	1.014	1.058	75.707	77.171
7	74.75	77.35	0.639	0.665	68.144	68.466
8	86.25	88.85	0.452	0.430	63.300	66.757
9	97.75	100.35	0.299	0.303	57.124	59.689
10	109.25	111.85	0.246	0.221	52.159	51.199
11	120.75	123.35	0.178	0.165	48.439	49.151
12	132.25	134.85	0.125	0.135	43.902	48.484
13	143.75	146.35	0.104	0.123	40.851	41.791
14	155.25	157.85	0.101	0.100	38.642	34.106
15	166.75	169.35	0.073	0.083	35.962	29.705
16	178.25	180.85	0.095	0.091	33.212	30.206
17	189.75	192.35	0.128	0.130	30.855	30.140
18	201.25	203.85	0.243	0.235	28.923	23.956
19	212.75	215.35	0.630	0.661	27.252	24.229
20	224.25	226.85	4.551	4.556	25.053	21.444

Edep for iris rings



EDEP INNERMOST IRIS



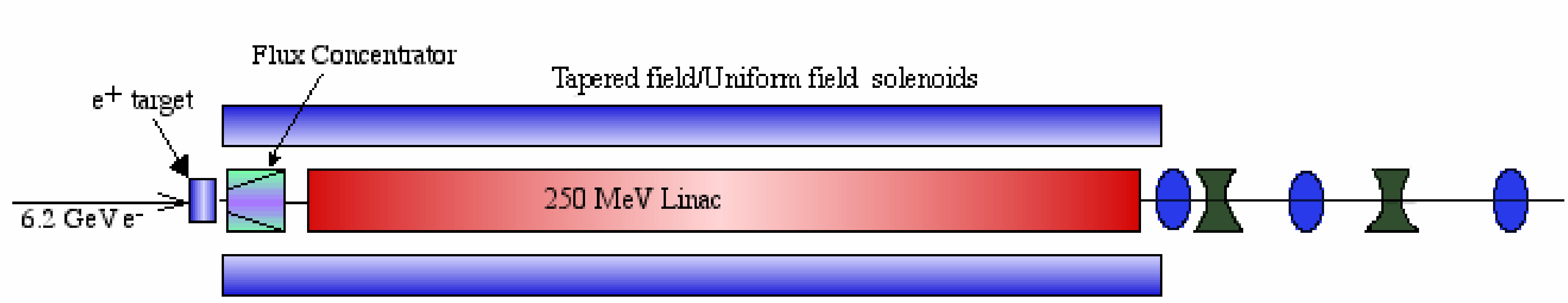
COMMENTS

- At the gross level calculations make sense
- Undulator based positron production is more forward peaked and does not produce neutrons
- “Solenoid” can be shielded – energy depositions are a fraction of a watt (use of an SC device may be feasible as far as heat deposition is concerned, but there may be other issues)
- Lot of energy deposited in the “l-band”, in the case of electrons this energy deposition is equivalent to the dump. How much gradient can we get for what duty factor.
- About 100-200 watts of energy makes it to the vault/vault air. Photons seem to deposit more at the vault than electrons. I think that it is because more energy flows backwards from the target and the pre-beam shield is not optimal. This needs to be understood.

Follow-on Studies

- Fluka Calculations
  - Better shield, cheaper shield, better layout, more realistic layout
  - When can on transition to SC L-band
- Radiation damage
  - What does deposited EM energy do
  - Is deposited neutron energy different/worse
- Solenoid
  - What field/field profile can be made with an SC device
  - Field/field profile vs. positron capture

Positron Injector Lattice Parameters (Yuri Batygin)



Flux concentrator

Length **0 < z < 15 cm**

Field at the target **1.2 Tesla**

Pre accelerator

Wavelength **21 cm**

Length **15 cm < z < 1000 cm**

Gradient **250 kV/cm**

Aperture **2.5 cm**

Focusing magnetic field **0.5 Tesla**

Accelerator

Wavelength **21 cm**

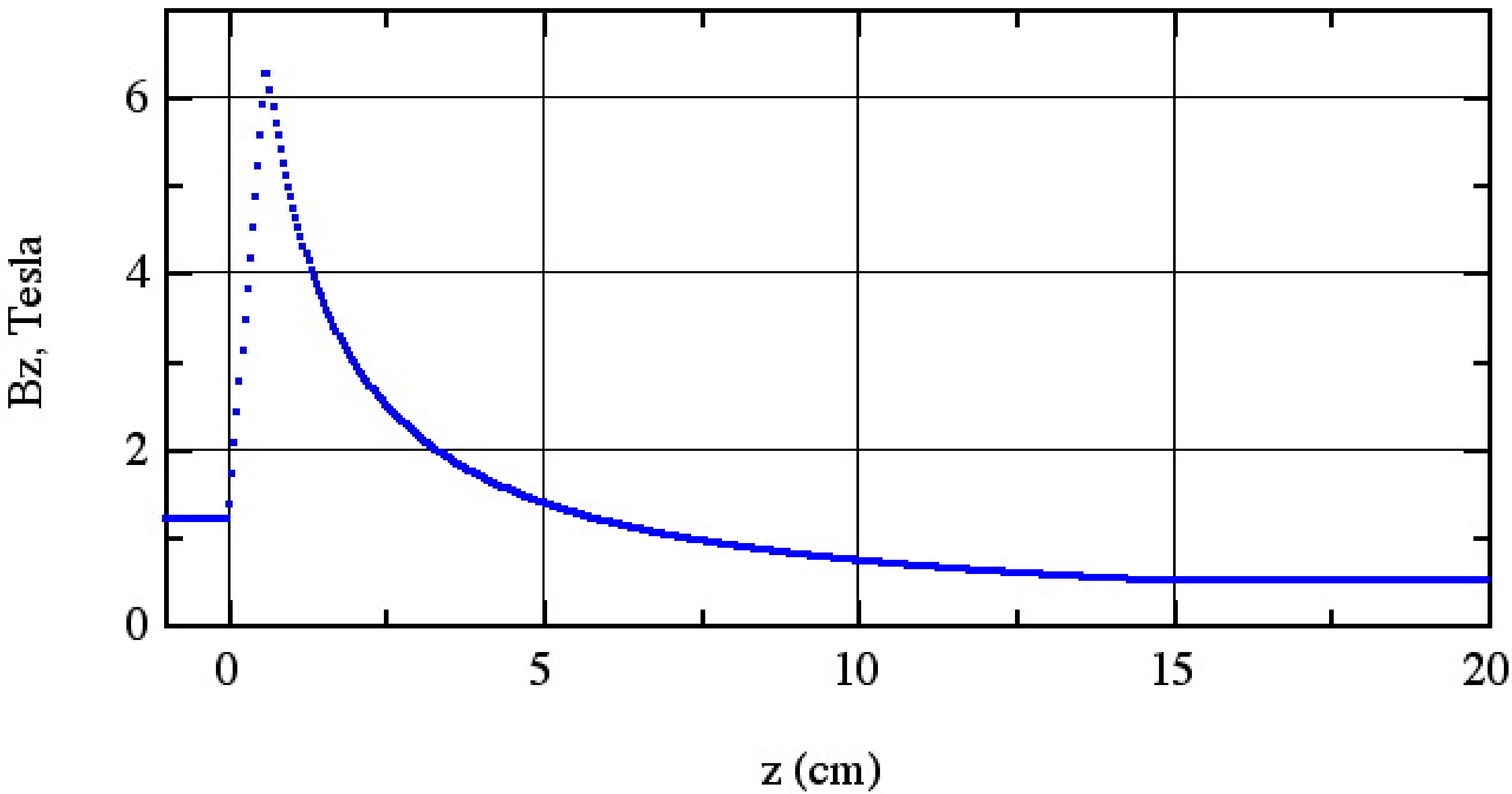
Length **1000 cm < z < 19010 cm**

Gradient **96 kV/cm**

Aperture **3 cm**

Focusing **Quadrupole structure**

Magnetic Field Profile of Flux Concentrator

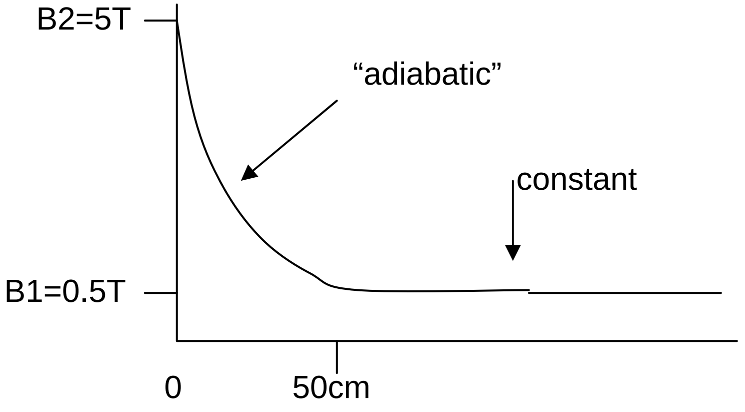


SC Solenoid for Adiabatic Matching Device for ILC Positron Source

Solenoid with ID ~ 1 meter, length a few meters

Heat load from beam is < 1W

Magnetic field profile



Questions

1. Is such a device possible
2. Largest possible value of B2
3. Smallest possible extent of the adiabatic part (is even 50 cm possible)
4. Smallest possible field & extent for Z<0 (would like it to be zero)
5. How well can "adiabatic" be controlled
6. How long is such a device

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11/30/2004

Follow on studies

- MARS
  - Program by Nikolai Mokhov (FNAL)
  - Extensively used at FNAL, ILC BD
  - Appears to have better input/output code
  - Specific advantages for us
    - Has RF
    - Calculates activation, dose
    - Calculates temp rise (heat capacity vs temp)
  - Can be basis of “start-to-end” (target-to-damping-rings) simulation of target and capture and transport system